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IRI 2007 VTEC PREDICTIONS FOR MIDDLE LATITUDE STATIONS IN THE NORTH AMERICAN SECTOR

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Abstract. The ability of the International Reference Ionosphere (IRI) model to make predictions of VTEC over Goose Bay and Boulder has been checked. The data correspond to 2006. The two IRI options for the topside electron density (N) profile, standard and NeQuick, have been considered. The results show that both options give similar results. In general, lowest values of VTEC are obtained with NeQuick. For Boulder, very good agreement between modeled and measured VTEC values are observed for June at nighttime hours. Overestimations in about 3 TECU are observed.

1 INTRODUCTION

The total electron content (TEC), defined as the number of free electrons in a column of 1 m^2 cross-section extending from the ground to the top of the ionosphere, is an ionospheric magnitude of great importance for systems which use transionospheric radio waves. When a radio wave traverses the ionosphere, several effects are produced in it. Most of these effects are proportional, at least to the first order, to the TEC. The ionospheric corrections that have to be applied to determine the satellite position accurately are proportional to the TEC along the radar-satellite path1. The knowledge of TEC as function of time, location and solar activity is important for geophysical and engineering applications. Modeled TEC values can be an useful tool for obtaining ionospheric corrections for affected systems. Diferent models have been developed to predict ionospheric

variables[2,3]. The Committee on Space Research (COSPAR) and the International Union of Radio Science (URSI) formed a working group to produce an empirical standard model of the ionosphere, based on all available data source. This model is called the International Reference Ionosphere (IRI)[4,5,6]. IRI describes the electron density (N) height profile and the vertical total electron content (VTEC). IRI is one of the most widely used empirical model. Several steadily improved editions of IRI have been released. The last version of this model IRI 2997 is avaliable through internet and also includes the NeQuick model[7] as a new option for the topside N-profile description. In previous work the validity of IRI in predicting the VTEC over Tucumn (26.8°S, 294.7°E; geomag. Lat.: 15.5° S), station placed near the Southern peak of the equatorial anomaly, using geosynchronous satellite signals received during 1982, has been checked[8] . The results showed that the model overestimates VTEC around the daily minimum and underestimates it the rest of the day. Using measurementes obtained with GPS signals received during 2000, the validity of IRI in predicting VTEC over Arequipa (16.5°S, 289.0°, mag. Lat.: 5.1°S) has been checked[9].The authors found that the model overestimates VTEC at nighttime and during sunrise and sunset. For some cases, good predictions have been observed for hours of maximum ionisation. GPS signals received during 1999 at nine south american stations were used to study the ability of IRI to make predictions of VTEC[1]0. The considered latitude range extends from 18.4N to 64.7S and the longitude ranges from 281.3°E to 287.7°E. The results obtained by those authors show that, in general, for June solstice and September equinox IRI overestimates VTEC at nighttime and sunrise hours. Better predictions were otained in the latitude range (18.4°N, 33.1°S) for the time period 8 22 LT. For high latitude stations, IRI did not give good predictions. In order to extend this study to other latitudes, in the present work we compare the IRI 2007 preditions with the GPS-VTEC measurements obtained at two middle latitude stations in the North American sector.

2 DATA

Measurements of vertical electron content (VTEC) over Goose Bay (53.3°N, 299.7°E), and Boulder (40°N, 254.7°E) obtained from GPS satellite signals received during June and September of 2006 ($15.6 \leq Rz12 \leq 16.3$), have been used. These data were obtained through National Geophysical Data Center (NGDC) web page. NGDC provides VTEC values over the Continental US (CONUS) for a given 15 minute interval in TEC units (1 TECU=10^16 electrons m^-2). The hourly monthly median values of VTEC were obtained. Measurements of critical frecuency of F2 region (foF2) obtained during 2006 with digital ionosondes at Goose Bay and Boulder were also considered. These data were obtained from the University of Massachusetts Lowell DIDBase11 through internet. Using foF2 the maximum electron density of the N-profile (NmF2) was calculated and used as input coefficient in the IRI model. For the present study monthly median values of VTEC were considered. We used median value because it has the advantage of being less affected by large deviations in the value of the ionospheric characteristics that can occur during magnetic storms.

3 RESULTS AND DISCUSSION

Taking into account that the modeled values correspond to a column of 2000 km of height and that measured VTEC correspond to a column which extends from ground to satellite height, it was expected that the masurements were greater than the model predictions. Figure 1 shows the obtained results. It can be seen that the predictions follow the shape of the experimental VTEC curve. Both options give similar results. In general, lowest values of VTEC are obtained with NeQuick. The greatest disagreements among predictions and measurements are observed for Goose Bay, June since 00 UT until 05 UT where the model overestimates VTEC in about 3 and 2 TECU with standard and Nequick options, respectively. For Goose Bay, June, very good predictions are obtained with NeQuick, in the time interval [08 UT - 16 UT] and with standard version since 17 UT until 22 UT. Similar results are observed for Goose Bay, September. For Boulder, the predictions are lower than the measurements, which is an expected result. The difference between measured and modeled values could be produced by the contribution of the plasmasheric electron content. A very good agreement between modeled and measured VTEC values are observed for June at nighttime hours suggesting that the plasmaspheric contribution is low for those cases.

4 CONCLUSIONS

1. The results show that IRI give similar results using both topside N-profile options. In general, lowest values of VTEC are obtained with Nequick.

2. Cases with very good agreement between predictions and measurements has been obtained for the considered stations. The worst predictions correspond to Goose Bay, June since 00 UT until 05 UT where the model overestimates VTEC in about 3 TECU.

3. Taking into account that the obtained results correspond to low solar activity, cases corresponding to other solar activities will be considered in the future.

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